Smart Crop Suitability System

Crop prediction and management system through soil nutrient testing

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Abstract - Agricultural industry plays a major role in the process of economic development as well as Gross Domestic Product of Sri Lanka. One of the significant issues in the industry is lacking an accurate way to identify the best crop that can be grown with the available soil fertility in a particular land. This research mainly focuses on suggesting the best crop according to soil fertility of a land and also it recommends a fertilizer plan to optimize amount of fertilizers applied for suggested crops. Since farmers have lack knowledge about soil nutrients, most of them start cultivations by believing myths in society and few of them use scientific approaches. This paper presents a tool with embedded sensors that measure soil fertility and developed a cross platform mobile application to suggest best crops according to available soil fertility. Further a fertilizer plan will be suggested to optimize fertilizer usage in order to increase profitability and avoid soil degradation. To evaluate the final product, same soil sample was tested in lab and using sensors embedded tool. Results obtained by those tests proven that both generate approximately equal Nitrogen (N), Phosphorus (P) and Potassium (K) values.

Keywords – Crop, Fertilizer, Soil nutrients, Soil degradation, Harvest

I. INTRODUCTION

People increasingly used to depend on machinery, rather than doing their daily basis manually, in order to save their time and effort. Recently this technique got more popular in cultivation field. Earlier days farmers had to use so much human power to fulfil their needs in cultivation. But now using a single machine alone with only one person to control it can gain the same amount of work with lesser time and lesser money.

Knowing the conditions which are required to grow the plant that farmers desired to grow, is the key point of a successful cultivation. Hence it requires to know the soil condition as well as the environmental conditions. Environmental conditions are not easy to predict when if famers start an outdoor plantation. By the way, farmers can apply different nutrient types as they wish to grow the plants so to identify the soil condition in specific area, farmers can perform a soil test. Soil test is a series of tests which helps to identify the nutrient level of the soil.

According to the information we gathered from the research centre, the most trusted and popular soil testing mechanism is testing the soil with the help of professionals in a laboratory. Nevertheless majority of the farmers don't have enough time to visit the laboratories hence they are begin without any knowledge about cultivation so they will believe

the myths people say about the best crops for a particular area and grow it without thinking much.

Starting a plantation with believing myths will not be a success in all the times. So we cannot be guarantee that it is the best option that the farmer can rely on. Soil conditions of a particular ground will vary with the time, so it will be helpful if the farmer notify time to time with a nutrient plan which helps to maintain the soil to gain more results from the cultivation.

If there is a way for people to identify the best plant according to the environmental conditions in the area and the soil type of their ground by their own, it will be a very helpful solution for the better results and to saves time.

The paper presents a solution based on IOT (Internet Of Things) and so that it leads to use technology on fulfilling cultivation purposes effectively and efficiently by getting correct information about nutrition conditions well as suggestions to grow crops.

II. LITERATURE REVIEW

Several techniques were proposed previously by various authors for Nitrogen phosphorous potassium prediction from humidity, EC, pH and temperature. Many of them used some lab testing's rather using relevant sensors. Our main goal is reduced time by using relevant sensors to get readings. Few techniques previously used are explained below.

In July 2017 group of researchers Sabina Rahaman, Harshitha M, Anusha R, Bhargavi Y [1]R, Chandana M from Department of Electronics and Communication Engineering BMS Institute of Technology, Bangalore 560064 have invented a research which detect NPK(Nitrogen, Phosphorus and Potassium) Ratio Level Using SVM Algorithm and Smart Agro Sensor System They have integrated a sensing module with an Image processing setup to monitor the essential details needed for plant growth from the soil.

As inputs, they have get Temperature/Humidity, Soil Moisture and pH level. Which means those things directly affect to the fertilizer level of the soil. Furthermore, Image Acquisition, enhancing the image using Grey scale analysis, Adaptive Histogram analysis and feature extraction Methods have used by the research team for better result.

They have analyzed these feature values comparisons with database feature extraction and Mutism is used to classify into ratio level of NPK indicating which Nutrient is low. And also, they have successfully given moisture level (dry/wet) of soil, humidity reading, and pH scale [1].

Mr. Khakal V.S., Mr. Deshpande. N. M, Mr. Varpe P. B. Department of E &TC, PDVVP COE Ahmednagar have research Measurement of NPK from PH value and they have used NPK Microsensors other than ph and temperature sensor and mainly they have prepared a desktop application for view the results so in our system it will be more user friendly to using a smart application [2].

A group of researchers Komal Abhang, Surabhi Chaughule, Pranali Chavan, and Shraddha Ganjave has done a research on soil analysis and crop fertility prediction after referring results gathered by testing the particular ground soil using normal lab tests done by the agricultural department.

The main aim of their System is to atomize current manual soil testing procedure. In their system they have built handheld device using pH meter which give pH value of soil. pH is negative log of hydronium ion mole per liter pH = - log [H3O+]. With help of this pH value they estimate NPK of that soil, which are necessary Macronutrients of soil [3].

They have trained crop database for their software model and we classified that particular soil sample into particular class using classification algorithm. Depending on class determined by their system they give list of crops suitable for that particular soil sample. Also provide suggestion of fertilizer for particular crop [3].

Researchers N. Sivakumar, T. Amudha and N. Thilagavathi in Bharathiar University, Tamilnadu, India has done a research on Development of a Novel Bio Inspired Framework for Fertilizer Optimization to optimize the quantity of fertilizers applied to crops by using Fruit Fly Optimization (FFO) algorithm.

FFO algorithm is a popular bio-inspired optimization algorithm, aimed to resolve complex optimization problems and is inspired by the foraging behaviour of fruit flies. Initially the individual fruit fly has its own random position value. Each fruit fly refers to a different quantity of fertilizer and best food position refers to the optimal quantity of fertilizers with minimum cost. To find the optimal values, the algorithm starts with randomly initializing the three dimensional position (x, y, z axis), referred to as three primary nutrients of fertilizers N, P and K respectively.

The random location in search space can be changed by generating the random value and by adding with the initial location value, by using random position. The new position value of each individual fruit fly is evaluated to check whether the destination quantity of fertilizer is reached or not. If not, the distance to the origin is identified first and then, the value of smell concentration(s) and the smell concentration function, also known as fitness function are estimated. The fitness function is used as the objective function for calculating the quantity of fertilizer and cost of fertilizer [4].

The researchers Joon-Goo Lee and Haedong Lee, Aekyung Moon in Electronics and Telecommunications Research Institute, Daegu, Korea has done a research on monitoring and the prediction of crop growth by using image processing technique.
They have gathered the required information such as location, size, leap area index, canopy of the crop and suggested the effective segmentation method of Crop of Interest (COI) at horticulture greenhouse. They have proposed to do their research in two ways. Such as,

- A colour image of the crop is segmented the green and non-green region.
- A depth image of the crop is removed near crops as rear crops and both sided crops.

They have tried to overcome the problems in the existing methods which use threshold of each colour channel. So to overcome those errors they have suggested to use a ratio of each colour channel that is strong on changeable illuminance. [5]

Researchers, B. MiloviC and V. RadojeviC has done a research on the importance of data mining in Agriculture. In order to maintain the growth of the selected crop and generate a fertilizer plan we need to handle widely distributed data set with the nutrient levels the plant need in different time periods. So data mining technique will be useful to organize the data set and gather the required data by using patterns and algorithms.
There are many types of data mining techniques we can use for agriculture according to their research [6].
Fig. 2 shows the process model they have used for the machine learning algorithm.

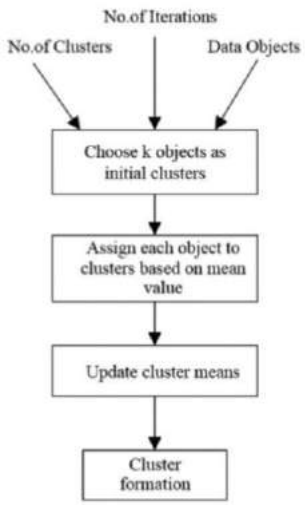

Figure 1 - Process model for machine learning [6]

Some of the types of data mining techniques they have used are listed below.

K-nearest neighbour in Agriculture – This algorithm is used in simulating daily precipitations and other weather variables and estimating soil water parameters and Climate forecasting.

Neural Networks in Agriculture - The neural network is used in Prediction of flowering and maturity dates of soybean and in forecasting of water resources variables in agriculture.

Decision tree in Agriculture – This algorithm is used for predicting soil fertility.

III. METHODOLOGY

Fig. 3 shows the high-level view of generating the expected output results of this research. Micro controller is able to read inputs, such as pH, Electrical Conductivity (EC), Humidity, Temperature sensor readings in the ground soil, and turn it into an output and publish in to fire base server.

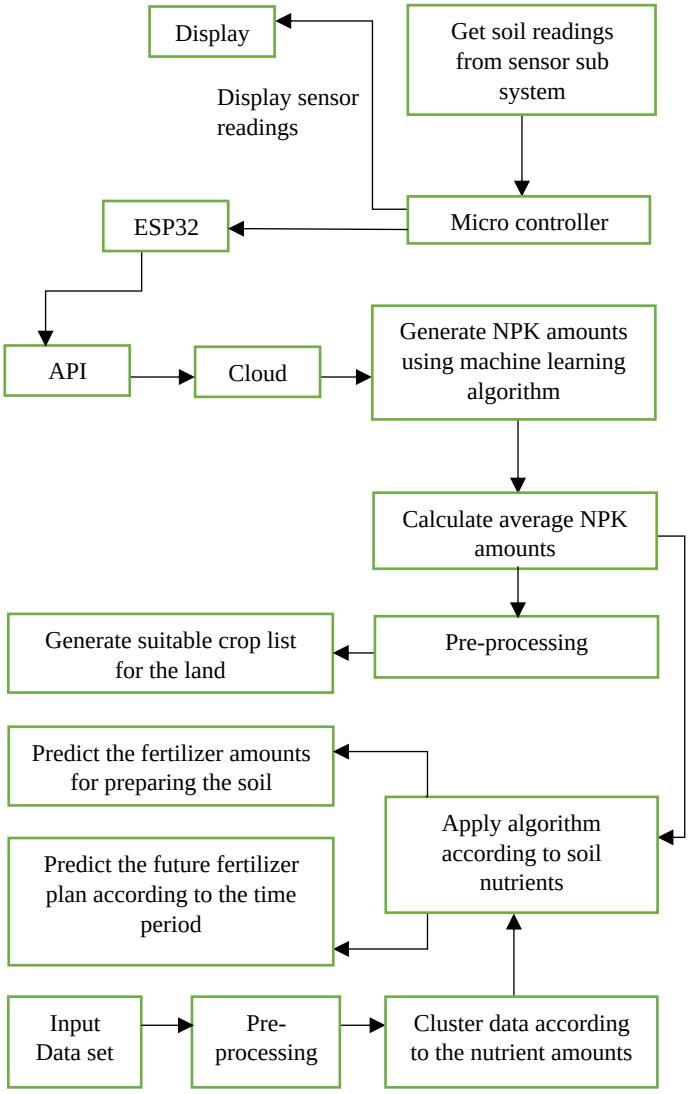

Figure 2 - High-level view of predicting the expected results

After gathering all the information, gathered data then redirecting to cloud using API gateway. Thereafter it predicts the average NPK amounts in the soil using relevant machine learning algorithm to predict the results. According to this research, the output results will be generated using SVM (Support Vector Machine) algorithm defining a co-relationship between pH, EC, Humidity and Temperature.

After building the model, the application will train the data set to get a better accuracy. To gain more accuracy, it is necessary to train at least 100 data sets with variant pH, temperature, EC and humidity level of soil.

It can achieve over 80% accuracy after building the model using the trained data set.

Authors deployed a cross platform mobile application and it facilitate farmers to select best crop for the land and maintain the growth of the cultivation with a better fertilizer plan. At the beginning farmer has to enter area of the land in meters. Then app automatically suggest the minimum reading count needed to take from the land.

Farmer has to take reading from the land using the proposed tool and when the required reading count is fulfilled, mobile application retrieve sensor reading from the cloud server, calculate average of sensor readings and display existing N, P, K percentages in soil. Then application analyse both soil type and existing nutrient levels in soil with in-built dataset in database and suggest list of most suitable crops that can be grown in that land.

Using a relevant machine learning algorithm, an optimized fertilizer plan is recommended for each suggested crop. It enables farmers to arrange the land according to the selected crop in order to increase profitability and reduce soil degradation.

Whenever the farmer selects a crop from suggested crop list, application retrieve fertilizer amount required to use in to the land for that selected crop using in-built fertilizer dataset in database. Using the data retrieved, it generates average N, P, K percentages that should exist in that particular land respectively

$$R = p \times \left(\frac{x}{a} \times m\right) \qquad (1)$$

Where,

R - Average nutrient percentages that should exist in land
p - Amount of a particular nutrient included in 1 Kg of fertilizer
x - Amount of fertilizer that should use for the selected crop
a - Area retrieved from database in m^2
m - Area of land in m^2

By comparing those generated nutrient percentages with soil existing nutrient percentages, nutrient deficiency of that particular land for the selected crop can be obtained. To overcome that deficiency, required amount of fertilizers that should use into that land is recommended.

$$F = f \times (R - e) \qquad (2)$$

Where,

F – Recommended fertilizer amount
f – Fertilizer amount that contain 1 Kg of particular nutrient
R - Average nutrient percentages that should exist in land
e – Land existing nutrient percentages

If by any chance farmer wanted to grow different crop other than crops included in suggested list, he can search for that crop details. If the requested crop can be grown in the land only by adjusting the existing nutrient levels in soil, app suggest the amount of fertilizer that should be used in order to plant that crop. So the farmer can make the land suitable for that crop to have a better harvest. This also helps to avoid soil degradation since there is no chance to use excess fertilizers.

According to the selected crop, the app will generate a fertilizer plan. It will vary with the soil nutrient levels of the relevant ground at that current time. Each and every crop requires different kinds of fertilizers in different times. The matching fertilizers that can be used for the growth of a single crop has so many varieties.

Specific crop has a specific amount of time that should apply the nutrients to the soil for a better growth. According to that time period the soil nutrients will be change due to climate changes. So, for the better accuracy the application will be using the soil nutrients that was generated by the sensor sub system in each time duration.

The data sets that have gathered in order to predict the future fertilizer plan are shown in the Table 1 and Table 2 below.

TABLE I - Amounts of NPK needed for the growth of Chili [7]

Chilli			
Application	**Kg/ha**		
	Urea	***TSP***	***MOP***
Top dressing 1	25	100	50
Top dressing 2	25	-	50
Top dressing 3	25	-	-
Top dressing 4	25	-	-
Total	100	100	100

TABLE II - Amounts of NPK needed for the growth of Big Onion [7]

Big Onion			
Application	**Kg/ha**		
	Urea	***TSP***	***MOP***
Basal	65	100	50
3 weeks after planting	65	-	-
6 weeks after planting	65	-	25
Total	195	100	100

Input data set has the specific fertilizers that should apply according to the time period, with respect to the nutrient percentages included in the fertilizer. The collected data will then be pre-processed and divide into different clusters according to the specific NPK amounts of each fertilizer, in order to have better idea about the total NPK amounts in all the fertilizers.

For the processing of predicting the fertilizer plan will be done by a machine learning algorithm. As the inputs, it provides the data set and the fertilizer amounts in soil according to the specific time period to the input layer. The hidden layers will maintain the calculations for predicting the specific amounts that should apply from each fertilizer. The output layer will maintain to show the predicted results to the user.

It will denote the total fertilizer amount (FA) that should apply by the following algorithm.

$$FA = \mathrm{h}\left[\mathrm{x}_1 * \left(\frac{\mathrm{a}_1}{100}\right) + \mathrm{x}_2 * \left(\frac{\mathrm{a}_2}{100}\right) + .. + \mathrm{x}_\mathrm{n} * \left(\frac{\mathrm{a}_\mathrm{n}}{100}\right) \right] \qquad (3)$$

Where,

FA – The total fertilizer amount
h - Hectares in the ground
x – The specific fertilizer
a – The amount that should apply from each fertilizer

The following table shows the dataset that we use to generate the results of the mobile application.

TABLE III - Crop Dataset

Crop	**Area(Acre)**	**Urea (N)**	**T.S.P (P)**	**M.O.K (K)**
Corn	2.5	75	100	50
Peanut	1	14	40	30
Mung bean	2.5	30	100	75
Soy Beans	1	50	100	75
Thala	1	20	48	24
Gram	1	14	40	30
Kaupi	1	14	40	30

IV. RESULTS

SVM algorithm is used to optimize the quantity Nitrogen, Phosphorus, Potassium application to various crops by analysing the different types of common fertilizers used in dry & wet zones, nutrient availability in soil and the nutrient requirement of crops. Fertilizer cost is also aimed to be minimized with optimization of fertilizers. Table 5 presents the optimal solution obtained by FFO to satisfy the NPK requirement of crops. The optimal values are arrived without considering the available NPK in the soil. The deviation between the actual (lab tested) NPK requirement and the system suggested value is very minimal and ranges between 0.5% and 2 %.

TABLE IV - Comparison of the NPK values

Sample No.		**Regular lab test Nutrient (Kg/Ha)**			**SVM Optimal Solution (Kg/Ha)**		
	Crops	***N***	***P***	***K***	***N***	***P***	***K***
1	Banana	90	45	45	89.40	44.40	44.40
2	Brinjal	300	100	200	299.83	99.83	199.83
3	Beans	210	35	450	209.86	34.86	449.86
4	Cucumber	30	60	30	29.07	58.07	29.07
5	Tomato	80	40	40	78.87	39.87	39.87
6	Sugarcane	70	35	35	68.89	34.89	34.89
7	Black gram	25	50	75	24.79	74.79	74.79
8	Chili	135	62	50	134.47	49.47	49.47

V. CONCLUSION

Since the early days of the agricultural era Sri Lankan Agricultures have played a strategic role in the process of economic development. Through this project we have analysed that we can make our agricultural industries more efficient and profitable with the aid of technology. This project puts forward a solution based on IOT. Through its methodology the effectiveness of such procedures is explained. For this we use the aid of pH sensors and moistens sensors. The project points out a procedure in which we can extract data from a specific agricultural land without assuming the status of the soil through plain insight also educates an individual about such procedures.

VI. REFERENCES

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